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AA387 AA389 AA409 AA41Y AA416 AA418 AA42X
AA422 AA425 AA428 AA44Y AA455 AA457 AA459
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AA525 AA527 AA529 AA53Y AA541 AA543 AA545
AA547 AA579 AA599 AA609 AA629 AA67X AA671
AA673 AA675 AA677 AA679 AA68X AA681 AA683
AA685 AA687 AA689 AA69X AA693 AA695 AA697
AA699 AA70X A748 A750 A751 A752 A781
U1S S1987 S2036

(56) Documents Cited

GB 2075548 A GB 1409628 A GB 1395125 A
GB 1210043 A GB 1209404 A

(58) Field of Search

UK CL (Edition L) C7A

(54) Precipitation-hardenable, nickel-based superalloy

(57) The alloy contains in percent by weight:-

Cr 11 - 15

Co 2 - 11

W 3.5 - 10

Al 3 - 5.5

Ti up to 3.5

Ta 4 - 9

with optional additions of

Mo 0 - 3, Zr 0 - 0.05,

B 0 - 0.05 and C 0.01 - 0.15.

The tantalum content is at least 1.5 times the titanium content. In this alloy, a gamma' phase, which is distributed in the form of particles in a surrounding matrix of material having a gamma phase, is formed by precipitation hardening. Before the precipitation hardening, the gamma' phase is completely dissolved by solution annealing. This alloy is substantially more suitable for the casting of directionally solidified components than nickel-based superalloys according to the state of the art and, in addition, has a creep life which is considerably improved as compared with these alloys.

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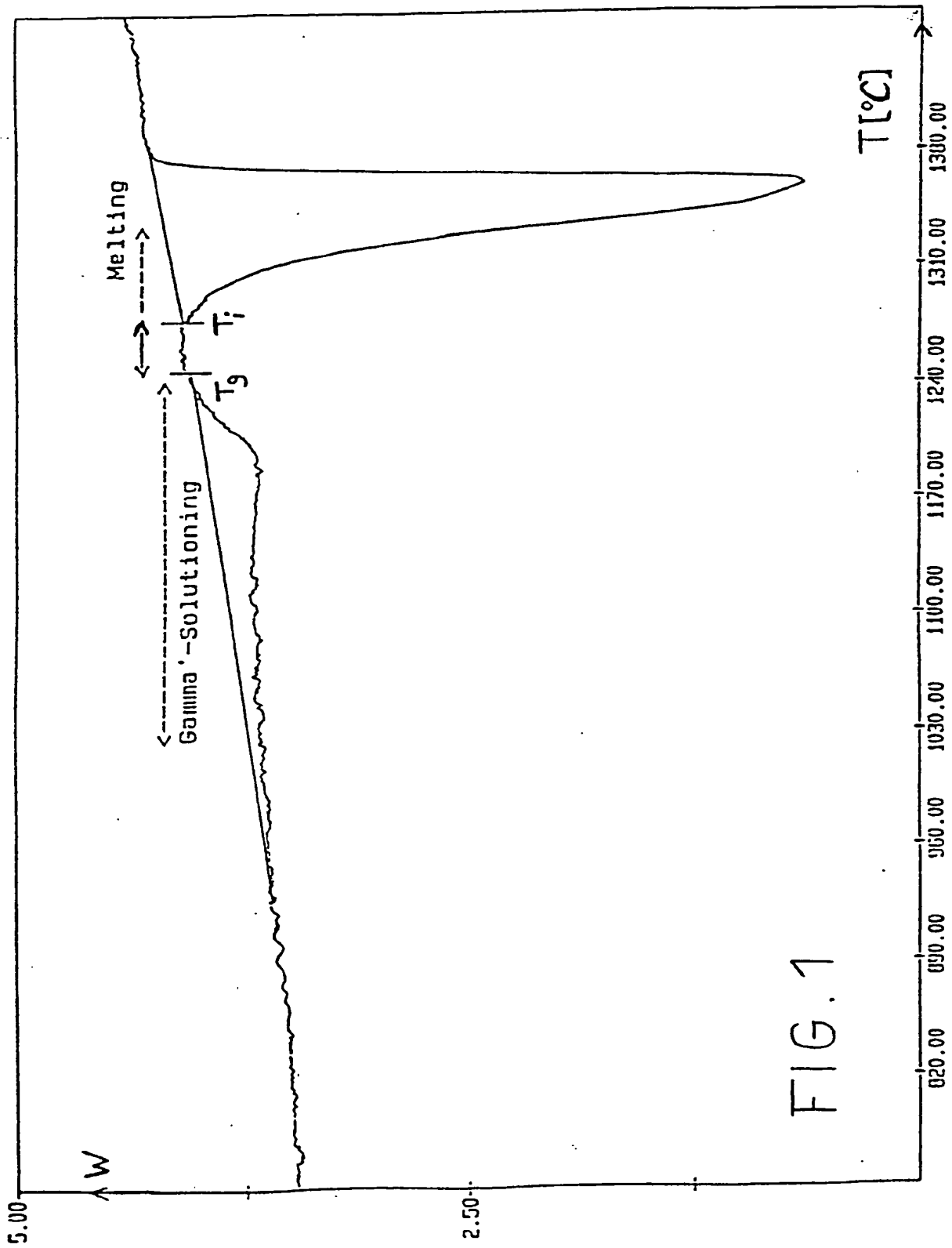


FIG. 1

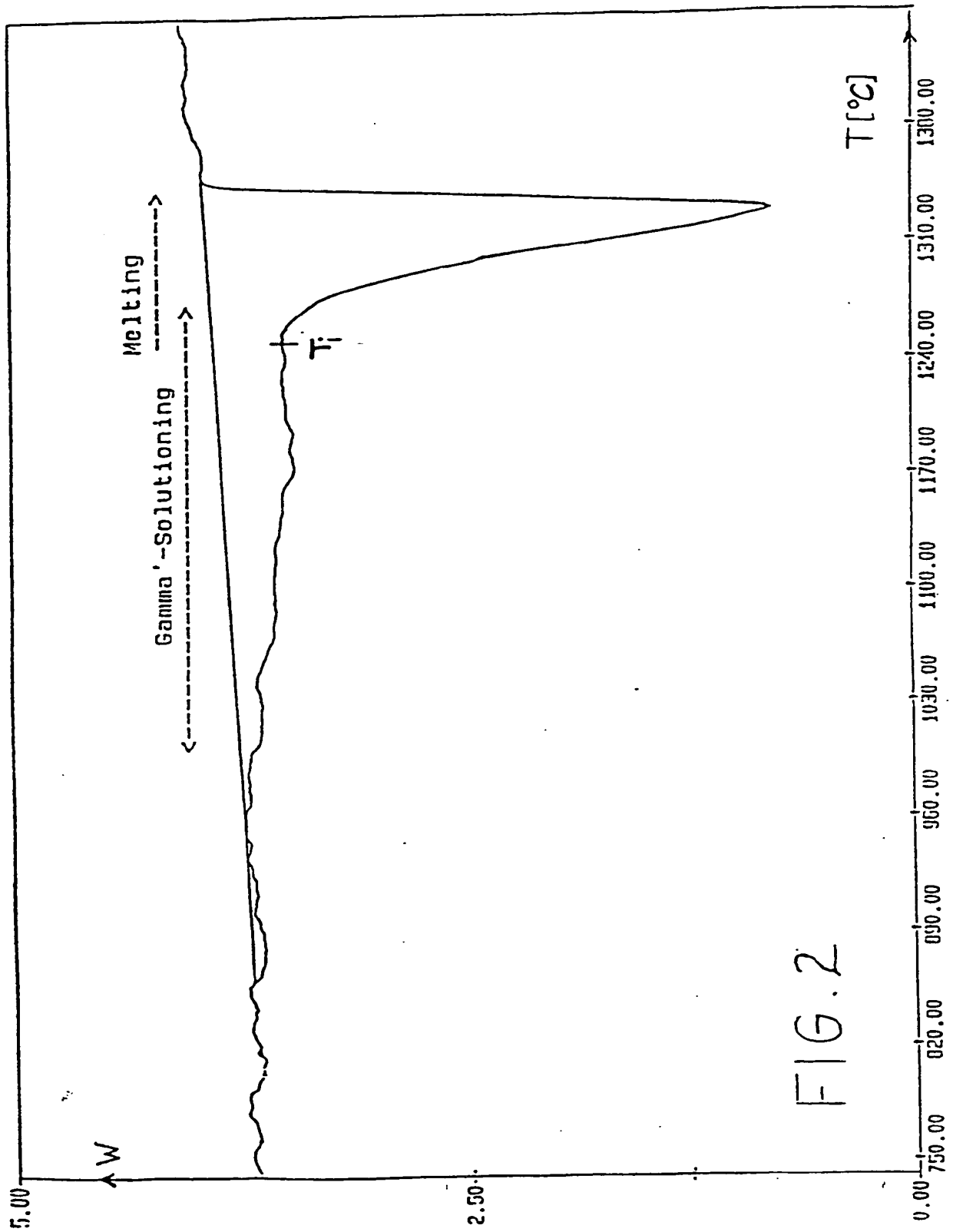
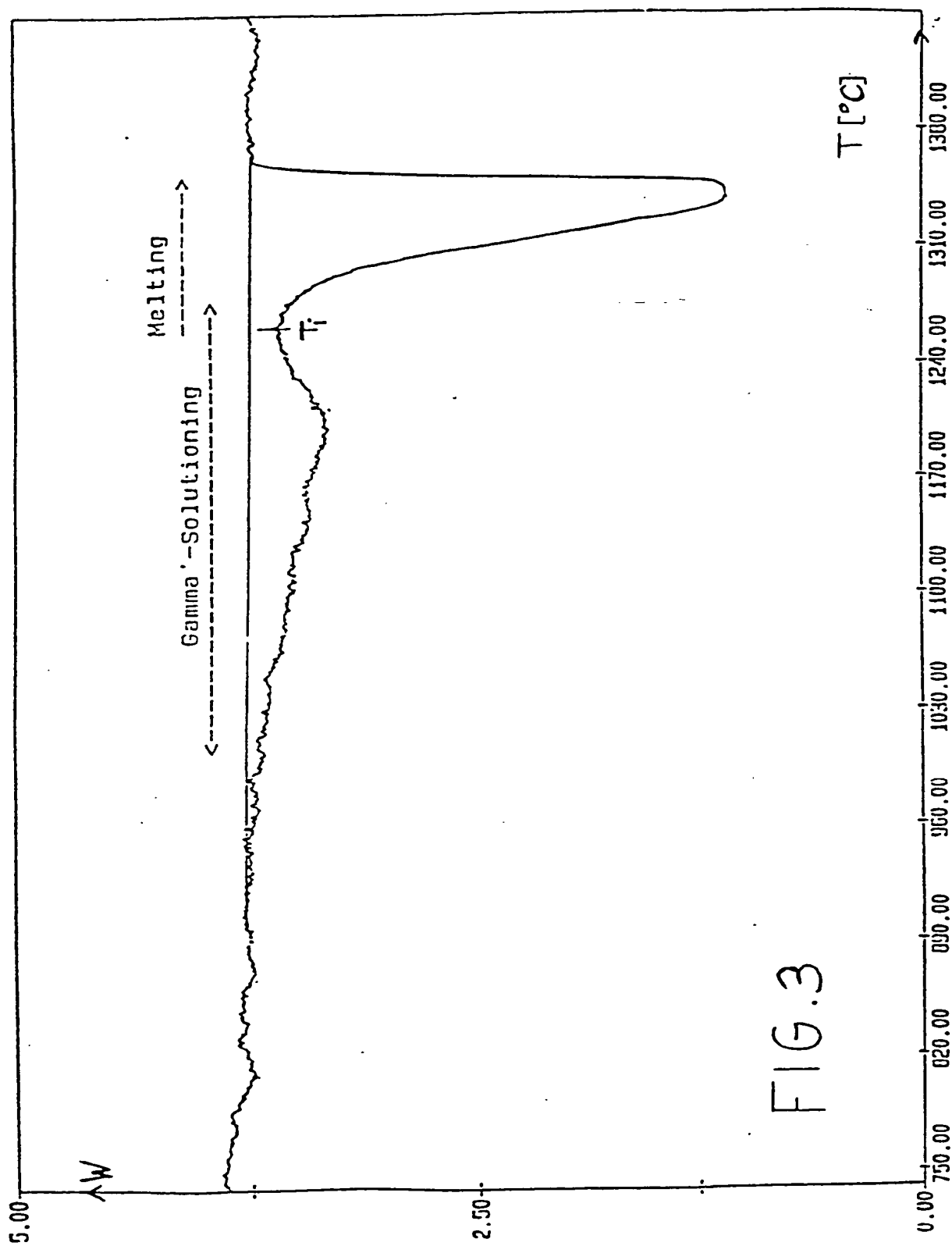


FIG. 2



TITLE OF THE INVENTION

Precipitation-hardenable, nickel-based superalloy and use of the alloy as material in the manufacture of a directionally solidified component such as, in particular, a gas turbine blade

BACKGROUND OF THE INVENTIONField of the invention

The invention starts from a precipitation-hardenable, nickel-based superalloy which contains, in addition to nickel, at least chromium, cobalt, tungsten, aluminum, titanium and tantalum as further alloy constituents. The invention also relates to a preferred use of the alloy.

Discussion of Background

The invention here refers to a state of the art, such as is evident, for example, from US-A-3,459,545, US-A-3,619,182 or US-A-4,957,703 for alloys having a chromium content of > 10 percent by weight, such as is required to ensure adequate corrosion resistance, for example in contact with sulfur-containing combustion gases in stationary gas turbines.

An alloy indicated in US-A-3,459,545 is frequently used as blade material for gas turbines. This alloy is distinguished by very high corrosion resistance at elevated temperatures. This is to be ascribed above all to the relatively high chromium content of the alloy of about 16 percent by weight. At the same time, however, the high chromium content also reduces the creep strength of the alloy. At a loading of 150 MPa/50,000 hours, such as is typical of stationary gas turbines, the tolerable metal temperature is restricted in the case of this alloy to about 820°C.

The nickel-based superalloys, which are described in US-A-3,619,182 and US-A-4,957,703 and can likewise be used as blade materials for gas turbines,

have, because of a lower chromium content, a creep resistance which permits use of the blade material at temperatures of up to about 850°C. An additional increase in the high-temperature strength by a further
5 reduction of the chromium content to less than about 10 percent by weight is not possible in the case of use in corrosive media, since an adequate chromium reservoir for the formation of a protective chromium oxide covering layer must be present.

10 However, by directional solidification, the use temperature of components of nickel-based superalloys can be yet further raised. In this case, stretched grain boundaries transversely to the preferential direction caused by the directional solidification are
15 eliminated, and the solidification conditions are selected such that this preferential direction coincides with the main loading direction in the component. Particularly in the manufacture of hollow components such as, for example, gas turbine blades which can be
20 cooled, from a material of conventional type, however, cracking open along longitudinal grain boundaries frequently occurs during the solidification step, whereby the component becomes useless. The causes of this are thermal stresses which are initiated by
25 different coefficients of expansion of the nickel-based superalloy and of a ceramic core required for the preparation of hollow components, and these stresses are not degraded by the material to a sufficient extent by plastic deformation.

30 According to D.N. Duhl and C.P. Sullivan "Some effects of hafnium additions on the mechanical properties of a columnar-grained nickel-base superalloy" Journal of Metals, July 1971, pages 38-40, the transverse ductility of the nickel-based superalloys can be
35 increased by addition of hafnium, which correspondingly reduces the cracking tendency. As a result, however, the melting point of the nickel-based superalloys is lowered to such an extent that complete dissolution of the gamma' precipitations during a solution-annealing

treatment is no longer possible. This leads to a reduction in creep resistance and at least partially cancels the favorable effect of the directional solidification. A further problem is that hafnium tends to react with the material of the mold shell which receives the nickel-based superalloys during manufacture. Particularly in the case of large components, a depletion of hafnium during the solidification step then occurs, so that an adequate improvement in the transverse ductility is then no longer ensured.

SUMMARY OF THE INVENTION

Accordingly, one object of the invention, as is defined in Patent Claim 1, is to provide a novel nickel-based superalloy of the type mentioned at the outset, which is substantially more suitable than nickel-based superalloys according to the state of the art for the preparation of directionally solidified components and whose creep life at high temperatures is improved as compared with these alloys.

Nickel-based superalloys according to the invention are distinguished by better castability and higher creep life than those of comparable nickel-based superalloys according to the state of the art. The improved castability arises, surprisingly, without addition of hafnium and can, at the same time, be exploited for the purpose that components, which have hitherto not been preparable in a directionally solidified form, can now be prepared with directional solidification, or that more efficient cooling concepts, for example, can now be realised, both cases leading to an increase in service life. Accordingly, components which have been manufactured from nickel-based superalloys according to the invention and are subjected to high temperatures, such as especially gas turbine blades, have a service life which, under the same conditions of mechanical loading and temperature, is several times longer than that of correspondingly sized components

consisting of nickel-based superalloys according to the state of the art.

5 These advantageous effects, which were not to be expected, of the nickel-based superalloys according to the invention are presumably to be ascribed to the fact that a particularly high stability of the alloy microstructure results from the reduction in the titanium content and the raising of the tantalum content. This is also a consequence of the complete dis-
10 solvability of the gamma' precipitations in a surrounding gamma matrix during the solution annealing. This possibility of complete dissolution arises, surprisingly, as soon as the tantalum/titanium weight ratio exceeds a value of 1.5. By increasing the content
15 of tantalum and, if appropriate, also that of tungsten, the microstructure stability and the creep strength are additionally improved. Due to the comparatively low content of titanium, however, the occurrence of a brittle etaphase containing Ni_3Ti is at the same time
20 also largely avoided. This eliminates the starting points for cracking along longitudinal grain boundaries, whereby the castability is substantially improved.

 In addition, an improvement in the castability
25 also results from the fact that "freckles" can now no longer form during the manufacture of directionally solidified components. Such "freckles" are equiaxial grains which are arranged in rows like a string of beads. They are formed in an unstable liquid layering
30 (light at the bottom, heavy at the top) which is connected with the enrichment of titanium in the interdendritic melt. The raising of the tantalum content (tantalum is heavy and likewise enriches interdendritically) and the lowering of the titanium content significantly reduce the formation of "freckles" and
35 thereby considerably improve the castability.

 Alloys according to the state of the art show a high positive mismatch $\delta a = (a' - a)/a$ between the lattice constants a of the matrix lattice and the

lattice constants of the gamma' precipitations contained in the matrix. This is a consequence of the comparatively high content of titanium and tantalum, which expand the lattice of the gamma' phase, and of the comparatively low content of tungsten, which expands the lattice of the gamma matrix. The high mismatch δa is greatly diminished by the reduction in the titanium content. This results in two very important advantages for the alloys according to the invention. On the one hand, the ductility is increased, whereby the cracking tendency during the directional solidification of the alloys according to the invention is reduced, since induced stresses can more readily be degraded by plastic deformations. On the other hand, at a small mismatch, the coarsening kinetics of the gamma' precipitations is slowed down, which leads to an improved long-term stability of the microstructure, i.e. to a higher long-term strength at high temperatures.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 shows a diagram in which the dependence of the heating effect W [relative units], determined by differential thermal analysis (DTA), of an alloy C according to the invention from the temperature T [$^{\circ}\text{C}$] is shown,

Figure 2 shows a diagram, determined correspondingly to Figure 1, for an alloy I according to the state of the art, and

Figure 3 shows a diagram, determined correspondingly to Figures 1 and 2, for an alloy H according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Alloys of the compositions indicated below in percent by weight were smelted in a vacuum induction furnace.

Alloy	A	B	C	D	E	F	G	H	I
Ni	<----- Base ----->								
Cr	12.0	12.0	12.0	12.0	12.0	12.5	12.5	12.0	12.4
5 Co	<----- 9.0 ----->								
Mo	-	-	-	-	-	1.85	1.85	-	1.87
W	9.0	9.0	6.0	5.7	5.0	4.1	4.1	6.0	4.0
Al	3.5	3.7	4.2	4.0	5.0	3.4	3.4	4.1	3.4
Ti	3.0	2.0	2.0	1.9	1.5	3.8	3.8	3.3	3.9
10 Ta	5.0	5.8	6.8	6.5	5.0	4.1	4.1	5.0	4.1
Zr	<----- 0.02 -----> 0.01								
Hf	-	-	-	-	-	-	0.45	-	0.87
B	<----- 0.015 -----> 0.013								
C	<----- 0.07 -----> 0.08 0.07 0.08								
15									

Bars of said alloys, directionally solidified after smelting in the vacuum induction furnace and having diameters in each case of about 14 mm and lengths in each case of 250 mm, and also hollow rotor blades of a gas turbine having lengths of likewise about 250 mm were cast. For all the alloys, the following casting parameters were set here:

Take-off speed: 8 mm/minute
 25 Casting temperature: 1550°C
 Shell temperature: 1550°C

The alloys F, G and I served as comparison alloys and correspond to alloys according to the state of the art, such as, for example, the alloy marketed by
 30 The International Nickel Company, Inc., New York, under the type description IN 792.

The bars of alloys A and F were subjected to the following heat treatment steps usual for alloys according to the state of the art:

1200-1250°C/4 hours (solution-annealing) + 1080-1120°C/
2-4 hours (precipitation-hardening) + 850°C/24 hours
(precipitation hardening).

Specimens having an overall length of 46 mm and
a diameter of 5 mm in the measurement section were pre-
pared from the directionally solidified bars. These
samples were stressed in tension at a temperature of
950°C with a preset fixed force, and the time to
rupture of the particular specimen was recorded. The
following values were determined in this way:

Alloy	Temperature [°C]	Tension [MPa]	Time to rupture [h]
A	950	250	153
A	950	225	243
A	950	200	636
F	950	250	83
F	950	225	126
F	950	200	204

It can be seen from this that a component of an
alloy of the composition A according to the invention
shows a creep behavior which is 2-3 times better and
hence has a correspondingly longer service life than a
component of an alloy according to the state of the
art.

With the same process parameters, two direc-
tionally solidified rotor blades, of hollow design for
cooling purposes and having the same dimensions, for a
stationary gas turbine were cast from the alloys C and
G at about 1400 to 1500°C. It was found that the blade
manufactured from the alloy G formed cracks along
longitudinal grain boundaries. On the other hand, no
cracks were detectable in the blade cast from alloy C,
even when very sensitive examination methods were used,
such as, for example, a penetration test with a
fluorescent fluid. As compared with the alloy G
according to the state of the art, the alloy C thus has
a castability which for the first time allows the use

thereof as a material in the manufacture of directionally solidified components of hollow design, such as, for example, in particular gas turbine blades which can be cooled. It is a particular advantage in this case that the good castability was obtained without a hafnium addition enhancing the castability of a nickel-based superalloy. In fact, on the one hand, a hafnium addition considerably lowers the melting temperature of nickel-based superalloys. As a result, the dissolution of the gamma' phase during the solution annealing is made more difficult or even impossible. On the other hand, hafnium tends to react with the mold shell receiving the melt, which can have an adverse effect particularly in the manufacture of large components.

By means of further casting tests, it can be shown that, in addition to the alloy C, further precipitation-hardenable nickel-based superalloys which, in addition to the nickel, contain at least chromium, cobalt, tungsten, aluminum, titanium and tantalum as further alloy constituents, have good castability, provided that the tantalum content is at least 1.5 times the titanium content in percent by weight.

To obtain good mechanical properties, above all the heat treatability of the nickel-based superalloys according to the invention is of particular importance, in addition to the castability. The gamma' phase can be dissolved only in the solution-annealing step carried out during the heat treatment. Only in that case is it possible to ensure a uniform distribution of gamma'-particles in the surrounding matrix material, to be ascribed to a gamma phase, during the further step of a subsequent precipitation heat treatment. If, however, the gamma' phase cannot be completely dissolved, predominantly gamma' particles of coarse shape and non-uniformly distributed in the gamma matrix result. This impairs the creep strength on the one hand and accelerates corrosion and oxidation on the other hand.

It has now been found by means of differential thermal analysis that, in alloys according to the invention, there is a broad temperature interval between the dissolution of the gamma' phase and the melting of the analyzed alloy sample. In this temperature interval, complete or at least almost complete dissolution of the gamma' phase is in general possible.

This can be seen, for example, from Figure 1. In this Figure, the heating effect of a phase-free comparison sample represents approximately a straight line. The heating effect of the alloy C, however, deviates from this straight line in the direction of an endothermic heat effect at temperatures above about 900 to 950°C, because of the start of the dissolution of the gamma' phase. At a temperature T_g of about 1240°C, the gamma' phase has been completely dissolved and, up to a temperature T_i of about 1280°C, the heating effect of the alloy C again corresponds to the heating effect of the comparison sample. As can be seen from a renewed endothermic heating effect, the alloy C begins to melt above the temperature T_i . With a slight increase in the heating rate, this melting step starts only a long time after the complete dissolution of the gamma' phase. Because of the comparatively large width of the temperature window bounded by the temperatures T_g and T_i , the gamma' phase can be completely dissolved even in an industrial heat treatment process, in which an exact constancy of the temperature is not feasible, without at the same time incurring the risk of local melting of the alloy occurring.

Further nickel-based superalloys according to the invention, such as, for example, the alloys A, B, D and E, also show a corresponding behavior. These alloys show, between about 1200 and 1300°C, temperature windows of about 30 to 50°C, in which heat treatment steps such as, for example, solution annealing can be carried out without the alloys starting to melt.

All these nickel-based superalloys are distinguished by the fact that their tantalum content exceeds

their titanium content in percent by weight by a multiple. As soon as the proportions by weight of tantalum and titanium become comparable with one another, the temperature window disappears and complete dissolution of the gamma' phase without incipient melting of the particular nickel-based superalloys is not possible. This can be seen from the DTA diagram according to Figure 2 of the nickel-based superalloy I, belonging to the state of the art, with a Ta/Ti weight ratio of about 1.05. In this alloy, the temperature T_i initiating the melting is considerably below the temperature at which the dissolution of the gamma' phase is complete. Accordingly, complete dissolution of the gamma' phase is not possible with this alloy and only gamma' particles of coarse shape and non-uniformly distributed result during the precipitation hardening. In combination with the poorer castability as compared with alloys according to the invention, the result, corresponding to alloy F, for directionally solidified components of this alloy, is a creep life which is 2 to 3 times shorter than that of alloys according to the invention.

In nickel-based superalloys, in which the content of tantalum is at least 1.5 times the content of titanium in percent by weight, almost the entire gamma' phase is dissolved before incipient melting. As can be seen from the DTA diagram of alloy H, shown in Figure 3, this is to be ascribed to the fact that, at a Ta/Ti ratio of about 1.5, the associated nickel-based superalloy admittedly no longer shows a temperature window which effects complete dissolution, but the heating effect very closely approaches the reference line of the comparison sample before the start of melting and after almost complete dissolution of the gamma' phase.

Since titanium contributes to a certain increase in strength of the gamma' phase, the titanium content should be at least 0.8 percent by weight. Correspondingly, the tantalum content should be at most 10 times the titanium content in percent by weight.

Nickel-based superalloys which, in addition to nickel, contain the following components, in percent by weight:

- 5 11.0-15.0 of chromium
- 2.0-11.0 of cobalt
- 3.5-10.0 of tungsten
- 3.0- 5.5 of aluminum
- up to 3.5 of titanium
- 4.0- 9.0 of tantalum
- 10 0 - 3 of molybdenum
- 0 - 0.05 of zirconium
- 0 - 0.05 of boron and
- 0.01-0.15 of carbon, with $Ta/Ti \geq 1.5$,

15 are particularly suitable for the manufacture of directionally solidified components such as, for example, turbine blades in particular.

20 By increasing the tungsten content to at least 5 percent by weight, the stability of the particles of the gamma' phase against coarsening and hence the long-term stressability or the creep strength of the nickel-based superalloys according to the invention additionally improved. Preferred alloys should therefore contain the following components, in percent by weight, in addition to nickel:

- 25 11.5 -14.0 of chromium
- 3.0 -11.0 of cobalt
- 5.0 - 9.5 of tungsten
- 3.0 - 5.0 of aluminum
- up to 3.5 of titanium
- 30 4.0 - 8.0 of tantalum
- 0 - 2 of molybdenum
- 0 - 0.05 of zirconium
- 0 - 0.05 of boron
- 0.01- 0.15 of carbon, with $Ta/Ti \geq 1.5$.

35 A particularly good creep strength is shown by nickel-based superalloys according to the invention, having the following compositions:

- Base Ni
- 11.5 -14.0 of chromium

3.0 -11.0 of cobalt
7.5 - 9.5 of tungsten
3.1 - 4.0 of aluminum
2.2 - 3.3 of titanium
5 4.4 - 5.8 of tantalum
0 - 2 of molybdenum
0 - 0.05 of zirconium
0 - 0.05 of boron
0.01- 0.15 of carbon, with Ta/Ti \geq 1.5,
10 and especially
Base Ni
11.8 -12.5 of chromium
5.0 -10.0 of cobalt
8.5 - 9.5 of tungsten
15 3.3 - 3.7 of aluminum
2.7 - 3.2 of titanium
4.8 - 5.3 of tantalum
0 - 2 of molybdenum
0 - 0.03 of zirconium
20 0.005- 0.03 of boron
0.02 - 0.10 of carbon.

Good creep strength and good castability is shown by nickel-based superalloys according to the invention, which, in addition to nickel as base metal,
25 have the compositions in percent by weight, indicated below:

11.5 -14.0 of chromium
3.0 -11.0 of cobalt
5.0 - 7.0 of tungsten
30 3.6 - 4.8 of aluminum
1.4 - 2.4 of titanium
5.6 - 7.3 of tantalum
0 - 2 of molybdenum
0 - 0.05 of zirconium
35 0 - 0.05 of boron
0.01- 0.15 of carbon

and also

11.8 -13.0 of chromium
5.0 -10.0 of cobalt

- 5.5 - 6.3 of tungsten
- 3.9 - 4.4 of aluminum
- 1.7 - 2.2 of titanium
- 6.4 - 7.0 of tantalum
- 5 0 - 2 of molybdenum
- 0 - 0.03 of zirconium
- 0.005- 0.03 of boron
- 0.02 - 0.10 of carbon.

10 Obviously, numerous modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

CLAIMS

1. A precipitation-hardenable nickel-based super-alloy which contains, in addition to nickel, at least
5 chromium, cobalt, tungsten, aluminum, titanium and tantalum as further alloy constituents, having the following composition in percent by weight:
11.0-15.0 of chromium
2.0-11.0 of cobalt
10 3.5-10.0 of tungsten
3.0- 5.5 of aluminum
up to 3.5 of titanium
4.0- 9.0 of tantalum
0 - 3 of molybdenum
15 0 - 0.05 of zirconium
0 - 0.05 of boron
0.01-0.15 of carbon
and a tantalum content which is 1.5 times the titanium content in percent by weight.
- 20 2. An alloy as claimed in claim 1, wherein the titanium content is at least 0.8 percent by weight.
3. An alloy as claimed in claim 1 or 2, wherein the tantalum content is at most 10 times the titanium content in percent by weight.
- 25 4. An alloy as claimed in any of claims 1 to 3, having the following composition in percent by weight:
11.5 -14.0 of chromium
3.0 -11.0 of cobalt
5.0 - 9.5 of tungsten
30 3.0 - 5.0 of aluminum
up to 3.5 of titanium
4.0 - 8.0 of tantalum
0 - 2 of molybdenum
0 - 0.05 of zirconium
35 0 - 0.05 of boron
0.01- 0.15 of carbon.
5. An alloy as claimed in claim 4, having the following composition in percent by weight:
11.5 -14.0 of chromium

- 3.0 -11.0 of cobalt
7.5 - 9.5 of tungsten
3.1 - 4.0 of aluminum
2.2 - 3.3 of titanium
5 4.4 - 5.8 of tantalum
0 - 2 of molybdenum
0 - 0.05 of zirconium
0 - 0.05 of boron
0.01- 0.15 of carbon.
- 10 6. An alloy as claimed in claim 5, having the following composition in percent by weight:
11.8 -12.5 of chromium
5.0 -10.0 of cobalt
8.5 - 9.5 of tungsten
15 3.3 - 3.7 of aluminum
2.7 - 3.2 of titanium
4.8 - 5.3 of tantalum
0 - 2 of molybdenum
0 - 0.03 of zirconium
20 0.005- 0.03 of boron
0.02 - 0.10 of carbon.
7. An alloy as claimed in claim 6, having the following composition in percent by weight:
11.5 -14.0 of chromium
25 3.0 -11.0 of cobalt
5.0 - 7.0 of tungsten
3.6 - 4.8 of aluminum
1.4 - 2.4 of titanium
5.6 - 7.3 of tantalum
30 0 - 2 of molybdenum
0 - 0.05 of zirconium
0 - 0.05 of boron
0.01- 0.15 of carbon.
8. An alloy as claimed in claim 7, having the following composition in percent by weight:
35 11.8 -13.0 of chromium
5.0 -10.0 of cobalt
5.5 - 6.3 of tungsten
3.9 - 4.4 of aluminum

- 1.7 - 2.2 of titanium
- 6.4 - 7.0 of tantalum
- 0 - 2 of molybdenum
- 0 - 0.03 of zirconium
- 5 0.005- 0.03 of boron
- 0.02 - 0.10 of carbon.

9.. An alloy as claimed in any of claims 1 to 8 which has a microstructure, obtained by precipitation-hardening, with a gamma matrix lattice and with gamma' precipitations which are contained therein and which have been almost completely dissolved in the matrix by solution annealing before the precipitation hardening.

10 10. The use of the alloy as claimed in any of claims 1 to 9 as material and the manufacture of a directionally solidified component such as, in particular, a gas turbine blade.

15

Amendments to the claims have been filed as follows

1. A nickel-based superalloy which has a microstructure, obtained by precipitation-hardening, with a gamma matrix lattice and with gamma' precipitations which are contained therein and which have been almost completely dissolved in the matrix by solution annealing before the precipitation hardening, said alloy having the following composition in percent by weight:

11,0 - 15,0 of chromium,
 2,0 - 11,0 of cobalt,
 3,5 - 10,0 of tungsten,
 3,0 - 5,5 of aluminium,
 0,8 - 3,5 of titanium,
 4,0 - 9,0 of tantalum,
 0 - 3 of molybdenum,
 0 - 0,05 of zirconium,
 0 - 0,05 of boron,
 0,01 - 0,15 of carbon,

remainder nickel,

wherein the tantalum content is 1.5 times higher the titanium content in percent of weight.

2. An alloy as claimed in claim 1, wherein the tantalum content is at most 10 times the titanium content in percent by weight.

3. An alloy as claimed in claim 1 or 2 having the following composition in percent by weight:

11.5 -14.0 of chromium
 3.0 -11.0 of cobalt
 5.0 - 9.5 of tungsten
 3.0 - 5.0 of aluminum
 up to 3.5 of titanium
 4.0 - 8.0 of tantalum
 0 - 2 of molybdenum

0 - 0.05 of zirconium

0 - 0.05 of boron

0.01- 0.15 of carbon.

4. An alloy as claimed in claim 3, having the following composition in percent by weight:

11.5 -14.0 of chromium

3.0 -11.0 of cobalt

7.5 - 9.5 of tungsten

3.1 - 4.0 of aluminum

2.2 - 3.3 of titanium

4.4 - 5.8 of tantalum

0 - 2 of molybdenum

0 - 0.05 of zirconium

0 - 0.05 of boron

0.01- 0.15 of carbon.

5. An alloy as claimed in claim 4, having the following composition in percent by weight:

11.8 -12.5 of chromium

5.0 -10.0 of cobalt

8.5 - 9.5 of tungsten

3.3 - 3.7 of aluminum

2.7 - 3.2 of titanium

4.8 - 5.3 of tantalum

0 - 2 of molybdenum

0 - 0.03 of zirconium

0.005- 0.03 of boron

0.02 - 0.10 of carbon.

6. An alloy as claimed in claim 5, having the following composition in percent by weight:

11.5 -14.0 of chromium

3.0 -11.0 of cobalt

5.0 - 7.0 of tungsten

3.6 - 4.8 of aluminum

1.4 - 2.4 of titanium

5.6 - 7.3 of tantalum
0 - 2 of molybdenum
0 - 0.05 of zirconium
0 - 0.05 of boron
0.01- 0.15 of carbon.

7. An alloy as claimed in claim 6, having the following composition in percent by weight:

11.8 -13.0 of chromium
5.0 -10.0 of cobalt
5.5 - 6.3 of tungsten
3.9 - 4.4 of aluminum
1.7 - 2.2 of titanium
6.4 - 7.0 of tantalum
0 - 2 of molybdenum
0 - 0.03 of zirconium
0.005- 0.03 of boron
0.02 - 0.10 of carbon.

8. The use of the alloy as claimed in any of claims 1 to as material and the manufacture of a directionally solidified component such as, in particular, a gas turbine blade.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

Application number

GB 9314791.6

Relevant Technical fields

(i) UK CI (Edition L) C7A

(ii) Int CI (Edition)

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

R B LUCK

Date of Search

4 AUGUST 1993

Documents considered relevant following a search in respect of claims 1-9

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2075548 (UNITED TECHNOLOGIES CORP)	1 at least
X	GB 1409628 (AVCO CORP)	1 at least
X	GB 1395125 (BALDWIN JF)	1 at least
X	GB 1210043 (INTERNATIONAL NICKEL LTD) see especially Alloy No 5 in Table I	1 at least
X	GB 1209404 (UNITED AIRCRAFT CORP) see especially Examples 1 and 3	1 at least

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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